

REMARKS

Upon entry of the present amendment, claims 1 and 3-8 will remain pending in the above-identified application and stand ready for further action on the merits.

Claim 1 has been amended, claim 2 has been cancelled and new claims 6-8 have been added. Claims 3-5 have been withdrawn from consideration.

The amendments made herein to the claims do not incorporate new matter into the application as originally filed. For example, the amendment to claim 1 finds support in claim 2, which has been cancelled, and at page 7, line 19. New claim 6 is based upon description at page 7, line 19 of the specification. New claim 7 is based upon description at page 11, line 15 of the specification. New claim 8 is based upon description at page 16, line 18 of the specification.

Accordingly, entry of the present amendment is respectfully requested.

Restriction/Election

It is affirmed that for the purpose of examination of the present application, Applicants elect, with traverse, Group I, Claims 1-2. The requirement is traversed because (1) there are overlapping technical features between the three groups of claims, and (2) there would be no undue burden on the Examiner to examine three groups of claims.

Further, Applicants submit that currently amended claim 1 is patentable, as explained below. Therefore, since claim 1 is patentable, claims 3 (composition) and 4-5 (device), which depend from claim 1, are also patentable.

Thus, Applicants respectfully request rejoinder and consideration of claims 3-5.

Unclear Description

At paragraph "5." on page 3 of the Office Action, the Examiner states that the molar ratio described on page 4, line 3 is unclear in the absence of a denominator each value of the range, i.e. between 0.7:1 and 0.9:1.

In this reply, the paragraph beginning at page 3, line 16 of the instant specification has been amended. Therefore, this issue has been rendered moot.

Rejection under 35 USC § 102(b)

At page 4 of the Office Action, the Examiner sets forth the following rejections:

- *A rejection of claim 1 under 35 USC § 102(b) over Japanese Patent Nos. 9-176294(JP 9-176294) or 10-158366 (JP 10-158366); and*
- *A rejection of claims 1 and 2 under 35 USC § 102(b) over Japanese Patent No. 64-65120 (JP 64-65120).*

Reconsideration and withdraw of each of these rejections is respectfully requested based on the following considerations.

The Present Invention and Its Advantage

The present invention relates to a liquid epoxy resin composition. The liquid epoxy resin composition can be used, for example, for semiconductor encapsulation which cures into a cured product that has improved adhesion to the surface of silicon chips and especially photosensitive polyimide resins and nitride films and improved toughness. The liquid epoxy resin of the present invention does not suffer a failure even when the temperature of reflow elevates from the conventional temperature of nearly 240°C to 260-270°C, does not deteriorate under hot humid

conditions as encountered in PCT (120°C/2.1 atm), and does not peel or crack over several hundred cycles of thermal cycling between -65°C and 150°C.

The presently claimed liquid epoxy resin composition is effectively adherent to the surface of silicon chips and especially photosensitive polyimide resins and nitride films, does not deteriorate under hot humid conditions as encountered in PCT (120°C/2.1 atm), and is fully resistant to thermal shocks. The composition is thus suited as an encapsulant for large die size semiconductor devices.

The inventors have found that when the epoxy resin and the aromatic amine curing agent of formulae (1) to (3) are used in a molar ratio of 0.7 to less than 0.9, the liquid epoxy resin composition becomes effectively adherent to the surface of silicon chips and especially photosensitive polyimide resins and nitride films, and significantly resistant to thermal shocks, and maintains satisfactory properties under hot humid conditions.

The prior art compositions comprising epoxy resin and amine curing agent contain a silane coupling agent as an essential component, which causes voids to generate when the resin compositions are poured or cured for the manufacture of flip chip semiconductor devices. To solve the voiding problem, the composition of the present invention is formulated such that the composition absent a silane coupling agent is highly reliable and effective as an encapsulant especially for large die size semiconductor devices.

The feature of the present invention is fully proved by Examples of the specification as well as the Declaration enclosed herewith.

For example, as is shown in Examples 9-11 of the Declaration of Mr. Kazuaki Sumita, who is a named inventor, the good effects can be exerted without a silicone-modified resin in the form of a copolymer.

If the molar ratio of the liquid epoxy resin (A) and the aromatic amine curing agent (B) is more than 0.9/1 $[(A)/(B)]$, the toughness K_{Ic} of at least 3.5 can not be obtained, and thermal shock would be inferior, as is proved by Comparative Examples 4 and 5.

Further, as is proved by Comparative Example 6, the incorporation of a silane coupling agent would cause voids.

Distinction over JP 9-176294 and JP 10-158366

JP 9-176294 discloses a liquid encapsulator comprising (a) a liquid epoxy resin, (b) an alkylated diaminodiphenylmethane, (c) a polybutadiene compound having an epoxy group, (d) a silane coupling agent having at least one functional group selected from the group consisting of epoxy group, amino group, and mercapto group in a molecule, and (e) an inorganic filler having the specific particle distribution.

In [0006], it discloses that the molar ratio of (a) the epoxy resin to (b) the aromatic amine curing agent (alkylated diaminodiphenylmethane), (a)/(b), is in the range of 0.9 to 1.2, and when the molar ratio is less than 0.9, i.e., the curing agent is excess, the unreacted amino group is left, resulting in inferior moisture resistance and inferior reliability. Thus, JP 9-176294 teaches away from the claimed invention, which recites “the liquid epoxy resin (A) and the aromatic amine curing agent (B) are present in a molar ratio (A)/(B) from 0.7/1 to less than 0.9/1”.

On the other hand, in the present invention, the total amount of the aromatic amine curing agent used herein should be such that the molar ratio of the liquid epoxy resin to the aromatic amine curing agent, (A)/(B), is in the range from 0.7/1 to less than 0.9/1 (preferably from 0.7/1 to 0.85/1). If the compounding molar ratio is less than 0.7, unreacted amine groups are left, resulting in a lower glass transition temperature and poor adhesion. **With a molar ratio in excess of 0.9, the K_{Ic} value lowers and the cured product becomes hard and brittle enough for cracks to form during the reflow operation.**

Moreover, in the liquid encapsulator of JP 9-176294, the silane coupling agent is blended as described above.

On the other hand, in the present invention, the silane coupling agent is not blended.

Accordingly, the present invention is not anticipated by and is not obvious over JP 9-176294 since the cited reference fails to disclose or suggest the “liquid epoxy resin (A) and the aromatic amine curing agent (B) are present in a molar ratio (A)/(B) from 0.7/1 to less than 0.9/1” as recited in claim 1, and teaches away from the present invention.

JP 10-158366 also discloses a liquid encapsulator comprising (a) a liquid epoxy resin, (b) an alkylated diaminodiphenylmethane, (c) a silane coupling agent having at least one functional group selected from the group consisting of epoxy group, amino group, and mercapto group in a molecule, and (d) an inorganic filler having the specific particle distribution.

In [0009], it discloses that the molar ratio of (a) the epoxy resin to (b) the aromatic amine curing agent (alkylated diaminodiphenylmethane), (a)/(b), is in the range of 0.9 to 1.2. When the molar ratio is less than 0.9, i.e., the curing agent is excess, the unreacted amino group is left, resulting in inferior moisture resistance and inferior reliability. Thus, JP 10-158366 teaches away

from the claimed invention, which recites "the liquid epoxy resin (A) and the aromatic amine curing agent (B) are present in a molar ratio (A)/(B) from 0.7/1 to less than 0.9/1".

Moreover, in the liquid encapsulator of JP 10-158366, the silane coupling agent is blended as described above.

On the other hand, in the present invention, the silane coupling agent is not blended.

Accordingly, the present invention is not anticipated by and is not obvious over JP 10-158366 since the cited reference fails to disclose or suggest the "liquid epoxy resin (A) and the aromatic amine curing agent (B) are present in a molar ratio (A)/(B) from 0.7/1 to less than 0.9/1" as recited in claim 1, and teaches away from the present invention.

Distinction over JP 64-65120

JP 64-65120 discloses a liquid epoxy resin composition comprises an aromatic amine. However, JP 64-65120 fails to disclose or suggest "the liquid epoxy resin (A) and the aromatic amine curing agent (B) are present in a molar ratio (A)/(B) from 0.7/1 to 0.9/1, and the composition has a toughness K_{Ic} of at least 3.5".

In Example 1 of JP 64-65120, the curing agent is "diaminodiphenylmethane:metaphenylene diamine = 4:6", and is used in an equivalent amount to the epoxy resin. Accordingly, the molar ratio of the epoxy resin to diaminodiphenylmethane is more than 1.

Accordingly, the present invention is not anticipated by and is not obvious over JP 64-65120 since the cited reference fails to disclose or suggest the "liquid epoxy resin (A) and the

aromatic amine curing agent (B) are present in a molar ratio (A)/(B) from 0.7/1 to less than 0.9/1” as recited in claim 1.

Rejection under 35 USC §103

At pages 5-6 of the office action, the Examiner sets forth the following rejections:

- *A rejection of claim 1 under 35 USC § 103(a) over Japanese Patent No. 60-92318(JP 60-92318) in view of JP 9-176294; and*
- *A rejection of claims 1-2 under 35 USC § 103(a) over Japanese Patent Nos. 1-152120 (JP 1-152120), 9-176287 (JP 9-176287), 10-158365 (JP 10-158365) and 10-231351 (JP 10-231351) in view of JP 9-176294 and JP 10-158366.*

Reconsideration and withdraw of each of these rejections is respectfully requested based on the following considerations.

Distinction over JP 60-92318

JP 60-92318 discloses an epoxy resin composition comprising an epoxy resin, a curing agent, and lanolin. It discloses that examples of the curing agent include acid anhydrides such as phthalic anhydride, succinic anhydride, aromatic amines such as methaphenylenediamine, diaminodiphenylsulfone, aromatic amine adduct and the like, aliphatic or alicyclic amines such as polymethylene diamine, methane diamine and the like, synthetic resin primary condensates such as phenol resin, cresol resin and the like, although not limited thereto. Among the above curing agents, the synthetic resin primary condensates phenol resin, cresol resin and the like from the electric property and heat resistance.

The cited reference also discloses that ratio of the epoxy resin and the curing agent is 0.5 to 1.5, preferably 0.8 to 1.2.

In its Examples, phenol novolak resin is used as the curing agent.

From the above disclosure of JP 60-92318, it is not expected that when the epoxy resin and the aromatic amine curing agent of formulae (1) to (3) according to the present invention are used in a molar ratio of 0.7 to less than 0.9, the composition having a toughness K_{Ic} of at least 3.5 is obtained, and the resulting liquid epoxy resin composition becomes effectively adherent to the surface of silicon chips and especially photosensitive polyimide resins and nitride films, and significantly resistant to thermal shocks, and maintains satisfactory properties under hot humid conditions.

Therefore, JP 60-92318 fails to disclose or suggest the present invention.

Distinction over JP 1-152120

JP 1-152120 discloses a resin composition comprising a liquid epoxy resin and an aromatic resin. In Example 1, 100 parts by weight of p,p'-diaminodiphenylmethane of an active hydrogen equivalent of 50 and 250 parts by weight of bisphenol A epoxy resin of an equivalent of 190 are used. In Example 2, 130 parts by weight of p,p'-diaminodiphenylsulfone of an active hydrogen equivalent of 65 and 280 parts by weight of bisphenol A epoxy resin of an equivalent of 190.

From the above disclosure of JP 1-152120, the inventive molar ratio and the toughness K_{Ic} value discussed above are not expected.

Distinction over JP 9-176287 and JP 10-158365

JP 9-176287 discloses a liquid epoxy resin sealing material comprises: (a) a liquid epoxy resin, (b) a liquid alkylated diaminodiphenylmethane, (c) an acrylonitrile/butadiene rubber having a vinyl group in its terminal, and (d) an inorganic filler, wherein the mixing weight ratio of the components is $(a)/[(a)+(b)]=0.65$ to 0.80 , $(c)/[(a)+(b)]=0.02$ to 0.08 , and $(d)/[(a)+(b)+(c)+(d)]=0.50$ to 0.80 .

JP 10-158365 discloses a liquid epoxy resin sealing material composed mainly of (A) a liquid epoxy resin, (B) a liquid alkylated diaminodiphenylmethane, (C) a polybutadiene having epoxy group and (D) an inorganic filler. The weight ratios of the components satisfy the following formulas; $(A)/[(A)+(B)]=0.65$ to 0.80 , $(C)/[(A)+(B)]=0.02$ to 0.05 and $(D)/[(A)+(B)+(C)+(D)]=0.50$ to 0.80 .

From the above weight ratio of $(A)/[(A)+(B)]$, it is calculated that $(A)/(B)$ is $0.65:0.35$ to $0.80:0.20$. The epoxy resin (A) is contained in a larger amount as compared with the curing agent (B).

Therefore, JP 9-176287 and JP 10-158365 fail to disclose or suggest the specific molar ratio (i.e. from $0.7/1$ to less than $0.9/1$) and the specific toughness K_{1c} as recited in claim 1.

Distinction over JP 10-231351

JP 10-231351 discloses a liquid injection sealing underfilling material comprising a liquid epoxy resin, a curing agent such as alkylated diaminodiphenylmethane, and a spherical filler.

In Examples 1 to 3, 100 parts by weight of liquid epoxy resins and 35 parts by weight of the curing agent *8 in the form of alkylated diaminodiphenylmethane of an equivalent of 65 are used (see paragraphs [0013]-[0016]). Therefore, the epoxy resin is contained in a larger amount as compared with the curing agent. Moreover, the epoxy resin composition of all of Examples 1 to 7 as well as Comparative Examples 1 to 7 contain coupling agent.

Accordingly, JP 10-231351 fails to disclose or suggest the subject matters of the present invention, i.e.,

“the liquid epoxy resin (A) and the aromatic amine curing agent (B) are present in a molar ratio (A)/(B) from 0.7/1 to 0.9/1,

the composition has a toughness K_{Ic} of at least 3.5, and

the composition is substantially free of an alkoxy-bearing silane coupling agent except that an alkoxy-bearing silane coupling agent is used for the surface treatment of the inorganic filler.”

Distinction over JP 9-176294 and JP 10-158366

As explained above, JP 9-176294 and JP 10-158366JP, which are also cited for the rejection under 35 USC §102, fail to disclose or suggest the “liquid epoxy resin (A) and the aromatic amine curing agent (B) are present in a molar ratio (A)/(B) from 0.7/1 to less than 0.9/1” as recited in claim 1, and furthermore teach away from the present invention.

Combination of the Cited References

In the Office Action, the present invention has been rejected over primary references (i.e. JP 60-92318, JP 1-152120, JP 9-176287, JP 10-158365 and JP 10-231351) in view of JP 9-176294 and JP 10-158366.

However, as explained above, JP 9-176294 and JP 10-158366 not only fail to disclose or suggest the features of the present invention, but also teach away from the present invention.

Thus, a person having ordinary skill in the art would not be motivated by such a combination of the cited references to arrive at the present invention as instantly recited in pending claim 1.

Accordingly, the present invention (claim 1 and dependent claims) are neither anticipated by nor obvious over the cited references.

CONCLUSION

Based upon the amendments and remarks presented herein, the Examiner is respectfully requested to issue a Notice of Allowance clearly indicating that each of the pending claims 1 and 3-8 are allowed under the provisions of Title 35 of the United States Code.

Should there be any outstanding matters that need to be resolved in the present application, the Examiner is respectfully requested to contact Gerald M. Murphy, Jr. (Reg. No. 28,977) at the telephone number below, to conduct an interview in an effort to expedite prosecution in connection with the present application.

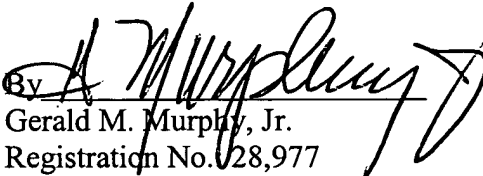
Application No. 10/618,765
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If necessary, the Commissioner is hereby authorized in this, concurrent, and future replies, to charge payment or credit any overpayment to Deposit Account No. 02-2448 for any additional fees required under 37 C.F.R. §§ 1.16 or 1.17; particularly, extension of time fees.

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Respectfully submitted,

By 

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Attachment: 37 CFR § 1.132 Declaration of Mr. Kazuaki Sumita